STEMming Up Plant Nutrients

Brief Description:

In this lesson students will identify and describe the functions of essential plant nutrients. This material assumes a basic knowledge of plant biological functions and fertilizer. If you feel your students need more background information see: www.nutrientsforlife.org

Objectives:

Upon completion of this lesson students will be able to:

1. Interpret fertilizer labels for proper application
2. Define nutrient leaching
    a. Identify the different categories of fertilizer and how they are relevant to nutrient leaching
3. Define the 4Rs of nutrient stewardship
4. Interpret possible plant nutrient deficiencies based on observable symptoms
5. Diagnose plant nutrient deficiencies
6. Apply the 4Rs of nutrient stewardship
7. Defend their application of the 4Rs of nutrient stewardship using a test garden

Materials:

The supplies needed for this activity will vary from project to project. Below is a list of useful items students might want to obtain. Recycled or upcycled materials should be used whenever possible. Hardware stores often offer donations for school garden projects.

- Copies of blank fertilizer label
- Copies of periodic table
- Bag of fertilizer (check your local feed and farm stores)
- Highlighters or colored pencils
- Fertilizer Labels
- Fertilizer Labels worksheet
- Live plants with different nutrient deficiencies or pictures of nutrient deficient plants (found on page 113)
- IFAS Soil Test Information Sheet and Analytical Services Lab Sheet
    - www.soilslab.ifas.ufl.edu

Time:

This time allotment does not account for the inclusion of the final enrichment activity.

Introduction: 45 minutes or one class period
Activity 1: 45 minutes or one class period
Activity 2: 40 minutes
Activity 3: 50 minutes (time may vary depending on time allowed to percolate)
Activity 4: 90 minutes

Preparation:

Teacher should read and understand all background material before beginning.

Vocabulary:

plant nutrients, 4Rs, fertilizer, nutrient leaching and plant nutrient deficiency

Background:

- Essential Plant Nutrient Functions (Nutrients for Life's Nourishing the Planet in the 21st Century Teacher Background, pp 20-21)
    - Scientists have identified 17 elements essential for plants. An element qualifies as being essential to a plant if the following conditions are met:
        - The element must be required by the plant to complete its life cycle.
        - The element cannot be replaced by another element.
        - The element is required for essential plant functions.
        - The element is required by a substantial number of different plant species.
    - Essential elements can be classified as mineral or non-mineral nutrients. Carbon, hydrogen and oxygen are classified as non-mineral because they are obtained through the atmosphere and water. Mineral nutrients can be further classified as macro or micronutrients. Macronutrients are needed in relatively large amounts. Nitrogen, phosphorus and potassium are called primary macronutrients; while calcium, sulfur and magnesium are called secondary macronutrients. The

Florida Standards:

SC.7.N.1.1, SC.7.N.1.4, SC.7.L.17.3, SC.8.N.1.1, SC.8.N.1.3, SC.912.L.17.1, SC.912.L.17.12, SC.912.L.17.15, SC.912.L.17.16, SC.912.L.17.17, MAFS.7.SP.1.1, MAFS.7.SP.1.2, MAFS.912.S-ID.2.5

remaining essential elements are called micronutrients because they are needed in relatively small amounts. Despite their name, however, micronutrients are just as essential to plant health as macronutrients.

Element Taken into the Plant	Symbol	Classification	Chemical Form
Hydrogen	H	Nonmineral nutrient	H_2O
Oxygen	O	Nonmineral nutrient	O_2 and CO_2
Carbon	C	Nonmineral nutrient	CO_2
Nitrogen	N	Primary macronutrient	NH_4+ and NO_3-
Phosphorus	P	Primary macronutrient	H_2PO_4- and HPO_{42}-
Potassium	K	Primary macronutrient	K+
Calcium	Ca	Secondary macronutrient	Ca_2+
Magnesium	Mg	Secondary macronutrient	Mg_2+
Sulfur	S	Secondary macronutrient	SO_{42}-
Boron	B	Micronutrient	$B(OH)_3$
Chlorine	Cl	Micronutrient	Cl-
Copper	Cu	Micronutrient	Cu_2+
Iron	Fe	Micronutrient	Fe_2+ and Fe_3+
Manganese	Mn	Micronutrient	Mn_2+
Molybdenum	Mo	Micronutrient	MoO_{42}-
Nickel	Ni	Micronutrient	Ni_2+
Zinc	Zn	Micronutrient	Zn_2+

- Fertilizer Labels-
  - The Florida Fertilizer Label- *Information for this section was derived from the edis article (http://edis.ifas.ufl.edu/ss170) unless otherwise stated. (Sartain.J)*
    - Fertilizer is responsible for approximately 50 percent of our world's food production. It is a vital ingredient used to grow strong and healthy plants – both in the garden and in the farm field. The connection between fertilizer and population is evident. As Nobel Peace Prize Winner Dr. Norman Borlaug explains, "This is a basic problem, to feed 6.6 billion people. Without chemical fertilizer, forget it. The game is over." *(Nutrients for Life)*
    - In order to protect its consumers, the Florida legislature enacted the first fertilizer law in 1889. These laws regulate the manufacture and sale of fertilizer in the state of Florida. While each state has autonomy over their fertilizer labeling laws, they must comply with Federal Fertilizer Regulations governed by the Environmental Protection Agency. The Association of American Plant Food Control Officials (AAPFCO) is the national organization of fertilizer control officials from each state, Puerto Rico and Canada responsible for administering fertilizer law and regulation. *(The Fertilizer Institute)*
    - Information on the Fertilizer Label
      - Florida License Number
        - Identified as a capitol "F" preceding the license number.
      - Brand Name
        - Name used by the licensee to identify the product.
        - Grade
          - Percentages of total nitrogen (N), phosphate (P_2O_5) and soluble potassium (K_2O) in fertilizer. Stated in whole numbers in that order.
      - Net weight
        - Actual weight present in package or container.
      - Name and street address of the manufacturer.
      - "Organic"
        - If used, this term indicates that water-insoluble nitrogen must not be less than 60 percent of the total guaranteed nitrogen stated.
      - "Guaranteed Analysis"
        - Divided into the percentage of total nitrogen (sum of all forms present), available phosphate, soluble potassium and a statement of each secondary plant nutrient present.
    - Total Nitrogen
      - Potential Forms of Nitrogen included- a statement of percentage of each form must be present.
        - Nitrate nitrogen
          - Includes all of the nitrate forms in the fertilizer mixture (NO_3^-).
        - Ammoniacal nitrogen
          - All of the ammonium forms of nitrogen.
        - Water-soluble nitrogen
        - Urea nitrogen
          - Urea, a white crystalline solid containing 46 percent nitrogen *(Overdahl.C)*
        - Water-insoluble nitrogen
          - Any water-insoluble source is used in this figure
            - Urea-formaldehyde, isobutylidene diurea, magnesium ammonium phosphate and other similar sources.
          - Many of these sources are treated in order to continually release nitrogen.
      - Without fertilizer, nitrogen becomes available to plants through the nitrogen cycle: (Nourishing the Planet in the 21st Century, www. Nutrientsforlife.org) See Figure 1. The Nitrogen Cycle.
        - Nitrogen fixation

- Process by which atmospheric nitrogen is converted to nitrogen containing compounds usable by plants. Fixation is accomplished through the action of lightning or microbial action in the soil.
- Ammonification
  - Bacteria and fungi convert decomposed nitrogen-containing compounds into ammonium cations.
- Nitrification
  - Process by which bacteria converts ammonium ions into nitrite. Still other bacteria convert nitrite into nitrate.
- Denitrification
  - Bacteria converts nitrates back to N2.

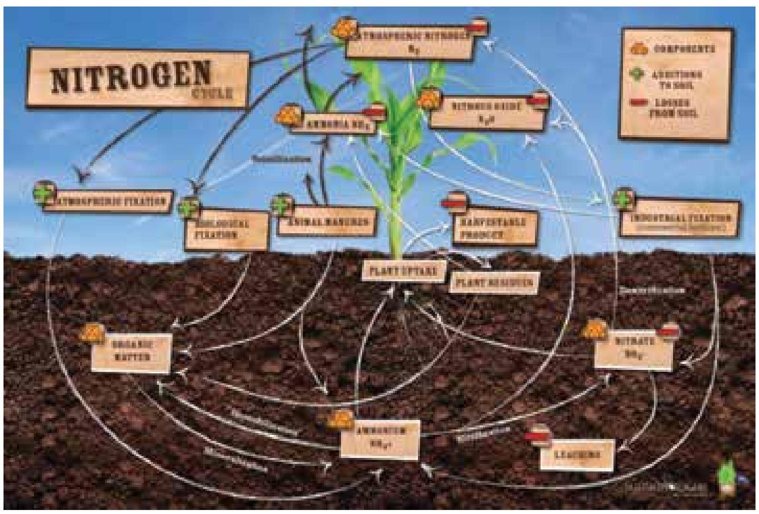


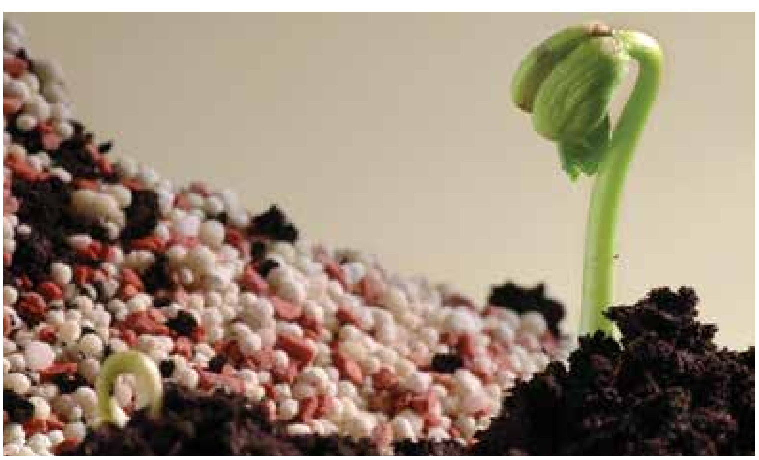
Figure 1: The Nitrogen Cycle (Nutrients for Life Foundation)

- Available Phosphoric Acid
  - Water soluble phosphorus plus a weak acid (citrate). Available as mono-basic phosphate ion (H2P4-) which is water soluble, or the dibasic phosphate ion (HPO42-) which is soluble in the weak acid citrate.
  - Other terms used: available phosphorus or available phosphate.
- Soluble Potash
  - The form of potassium in fertilizer is the potassium ion, K+. All of the potassium guaranteed on a fertilizer label is immediately available for plant uptake when applied to the soil.
  - Other terms used: soluble potassium
- Total Available Primary Plant Nutrients
  - Sum of the total nitrogen, available phosphate, and soluble potash. Exhibited in three figures accordingly: 10-20-10, known as the guaranteed analysis. The sum of these figures (40 in the case of the numbers used above) makes up the grade of the mixture.
- Chlorine- stated as "not more than" because of tendency toward toxicity toward many plants.
- Derived From- states the actual source materials for primary and secondary nutrients.
- Micronutrients:
  - Specifies secondary nutrients are present in elemental form.
  - Stated as "total"/ "water-soluble"/ "soluble" depending on source.
    - Magnesium (Mg)
    - Iron (Fe)
    - Zinc (Zn)
    - Copper (Cu)
    - Manganese (Mn)
  - Sulfur must be stated as "combined" or "free" unless product is classified as "Specialty Fertilizer."

- Nutrient Leaching and the 4Rs
  - As defined by Lehman and Schroth in "Chapter 7 Nutrient Leaching;" nutrient leaching is the downward movement of dissolved nutrients in the soil profile with percolating water. Nutrients moving below the rooting zone are (at least temporarily) unavailable to the plant. Leached nutrients have the potential to contribute to groundwater contamination. *(Lehman)*
  - Controlling nutrient loss means identifying its sources and implementing management practices that limit the loss of nutrients to the environment. Nutrient pollution, in part, caused by the excessive used of plant nutrients can cause algal blooms. These blooms damage waterways when the algae dies off and decomposing algae depletes the dissolved oxygen in the water used by marine species. (Nourishing the Planet in the 21st Century, *Nutrients for Life Foundation*)
  - According to the Natural Resource Conservation Service's Leaching Index (LI) *(Hurley)*.
    - To see step-by-step nutrient management plans visit www.nrcs.usda.gov
      - LI > 10 inches indicates a HIGH risk of leaching below the rootzone.
      - LI of five to 10 inches indicates a MODERATE risk of leaching below the rootzone.
      - LI < five inches indicates a LOW risk of leaching below the rootzone (Pierce et al, 1991).
  - 4Rs descriptions listed below are from *Nourishing the Planet in the 21st Century* (Nutrients for Life Foundation)

- The fertilizer industry endorses a best management practice (BMP) known as 4R Nutrient Stewardship. *(The Fertilizer Institute)*
  - Right Source: The type of fertilizer used matches the crop's needs.
  - Right Rate: Fertilizer is applied at a rate that the plant can use. If the rate it too slow then optimal yields will not result. If the rate is too fast, fertilizer (and money) will be wasted and nutrients will possibly leak into the environment.
  - Right Time: Fertilizer should be applied when the crop needs the nutrients.
  - Right Place: Ensure nutrients are applied where plant roots can most easily access them. The goal is to limit nutrient losses. Avoid environmentally sensitive areas such as those close to surface waters so nutrients will not run off or leach into surface/groundwater.

- Nutrient Deficiencies (derived from Nourishing the Planet in the 21st Century, *Nutrients for Life Foundation*) unless otherwise stated.
  - Plants grown in depleted soils may display a wide variety of symptoms and limit the quantity and quality of harvested crops. Fertilizers or plant nutrients, are essentially "plant food." When added to soil in the proper amounts, fertilizer replenishes nutrients people indirectly extract from the soil when harvesting plants. The essential components of most fertilizers are the macronutrients nitrogen (N), phosphorus (P) and potassium (K). Each of these play a key role in allowing plants to access the free energy of the sun through photosynthesis; and must be present in adequate amounts to ensure healthy crop growth.
    - Nitrogen (N)-
      - The primary building block for all organisms, nitrogen is a component of every amino acid and is vital in protein manufacture. As part of the chlorophyll molecule, nitrogen helps keep plants green; and along with magnesium is the only element in the chlorophyll molecule plants obtain from the soil.
      - Vigorous plant growth is associated with adequate nitrogen nutrition, in part, because nitrogen plays a key role in cell division. Of course, cell division is essential to adequate leaf surface area; without which photosynthesis would be limited and crop yields greatly reduced.
      - Nitrogen deficient plants will present leaves that are light green to yellow, they will have low protein levels and poor fruit development.
    - Phosphorus (P)-
      - Can be found in every living cell. Serves as both a structural element and a catalyst for biochemical reactions. Phosphorus is the main component of DNA and ATP (the cell's energy molecule). It also plays vital roles in capturing sunlight during photosynthesis, helping with seed germination and the efficient use of water in the plant. Phosphorous also aids in overall plant hardiness and susceptibility to disease.
      - Phosphorus deficient plants will exhibit purple colored leaves, stunted growth and delay in development, increased disease and reduced drought tolerance.
    - Potassium (K)-
      - While not crucial to any important plant structure, it plays critical roles in several physiological functions: activates enzymes that catalyze chemical reactions involved in growth; balances water by regulating the opening and closing of the stomates; and assists in the regulation of rate of photosynthesis through its role in the production of ATP. Other aspects of plant health influenced by potassium include growth of strong stalks, protection from extreme temperatures, and the ability to survive stressors such as weeds and insects.
      - Potassium deficient plants will show yellowing edges of older leaves and dead leaves. A potassium deficiency will also result in irregular fruit development and reduced drought tolerance.



Introduction:

1. Students will use a periodic table to identify nutrients needed by plants and then discover what impact each nutrient has on the plants. Start with the periodic table and identify macro, secondary, non-mineral and micro nutrients plus the function of each of the 17 in growing plants.

a. Ask students, "What do plants need to live?" and record their answers somewhere everyone can see. Possible responses are carbon dioxide, water, sunlight, sugar (a product of photosynthesis).
b. Hold up a fertilizer bag and ask, "What about this? What is this? What does it do?" Possible responses are plant food, fertilizer, compost. It feeds the plants -> use guiding questions to elicit responses along the line of "plant food."
c. Ask students, "Do plants eat?" Make sure that students understand that plants do NOT eat. Plants absorb nutrients from the soil as they take in water.
d. If not previously discussed, talk with students about plant structures, including phloem and xylem, and capillary action.

2. Placing students into groups, instruct them that they are going to be designing an experiment to demonstrate how a plant carries water and nutrients from the bottom to the top. Suggested materials given to groups are: celery, white flower such as carnation, water, glass or jar, food coloring or similar item, measuring cups. Or you can just use celery as a demonstration with the entire class.
3. Use celery to demonstrate how plants carry water and nutrients from bottom to the top. You will need to cut a piece of celery off the stalk, leaving the leaves. Place ¾ to one cup of water in a clear glass and add food coloring and stir. Place the celery in the colored water. Have students observe what is happening.
   a. Directions for Celery Demonstration:
      i. Pour 215 mL (approximately seven ounces) of water into a glass jar.
      ii. Add six to eight drops of food coloring (blue or red work best).
      iii. Cut one stalk of celery so it is 20 centimeters in length
      iv. Be sure to leave the leaf end on.
      v. Place cut stalk into jar with food coloring and water.
      vi. Observe results the next day.
      vii. This quick demonstration shows that plants take water (along with nutrients) UP from the roots to the rest of plant, explaining why we add nutrients to the soil.
   b. Ask students, "How and why is the colored water moving up the celery?" The xylem is a pipeline that moves water and nutrients up into the plant and to the leaves. This is how plants "eat" and why fertilizer must be soluble.

Activity 1: Essential Plant Nutrient Funtions

1. Begin by giving each student a copy of the *Blank Florida Fertilizer Label* (Sartain. J) and *Simple Periodic Table of Elements*.
2. Have students highlight or use colored pencils to color in the elements on their periodic tables they find on their blank fertilizer labels. Be sure to point out the similarities. Discuss with students that any element found in the periodic table is natural and "from the earth." When different elements are put together they are called compounds.
3. Ask, "Given what you've just seen, what is fertilizer?"
   - Possible responses: elements, compounds, molecules, chemicals (if students say chemicals point out that any combination of elements on the periodic table is considered a chemical, some chemicals are beneficial to humans, some are harmful).
4. Students are going to focus on the three key nutrients: nitrogen (N), phosphorus (P) and potassium (K).
   - Jigsaw or divide students into home groups of three to six students. Then divide each home group into three expert groups for N, P and K (more than one student from a home group can go to the same expert group as long as there is at least one person from each expert group). When students come back to their home groups from their expert groups they will teach everyone else in their group what they learned about N, P or K.
   - Expert groups should visit the following sites (The Fertilizer Institute): If internet is not available there is information for each group at the end of the lesson.
     - Nitrogen: https://www.tfi.org/introduction-fertilizer/nutrient-science/nitrogen
     - Phosphorus: https://www.tfi.org/introduction-fertilizer/nutrient-science/phosphorous
     - Potassium: https://www.tfi.org/introduction-fertilizer/nutrient-science/potassium
   - Use the table below as a guide: Expert Tip! Have each home group complete one chart as a team. Flipchart paper or large copy paper works best. Be sure to encourage students to use lots of color!

	Nitrogen	Phosphorus	Potassium
What is it?			
Where does it come from?			
How is it helpful to plants?			

Activity 2: Fertilizer Labels

1. In this activity students will interpret fertilizer labels for proper application rates.
   - Fertilizer Label Scavenger Hunt
     - The teacher will need to have at least four different fertilizer bags, boxes or bottles all with a label that can easily be read by the student. If this is not possible the teacher can use the four pictures of fertilizer labels found on pages 110 and 111. Sample fertilizer labels should be placed around the classroom to allow students to move around freely. After explaining the assignment, allow students to circulate around the classroom collecting information from the fertilizer labels. Expert Tip! A great way to have fertilizer labels around the room is to either enlarge them using your copy machine or recreate them on flipchart paper.
       - Each fertilizer label needs to be colored coded blue, orange, green or purples. Each student needs a *Fertilizer Label Scavenger Hunt Worksheet*. Students will write information on the worksheet for the label that matches the information. For example, Brand Name is in blue so student will write the brand name for the fertilizer coded blue.

Activity 3: Nutrient Leaching and the 4Rs

1. In this activity students will be able to understand nutrient leaching through a hands-on experiment. Students will also be able to identify the different categories of fertilizer and how they are relevant to nutrient leaching.
2. Students will be conducting a "Blue Dye Test" that will allow them to see how soil permeability relates to nutrient leaching. You can allow students to design their own experiment or conduct the one below. (Hochmuth, G.)
   - Materials
     - One cup quartz sand (clean sandbox sand is a good option)
     - ¼ cup dye (iodine or food coloring) mixed with ¼ cup water
     - Clear glass jar (volume of at least eight ounce)
   - Procedures
     - Measure one cup of clean, dry quartz sand and place it into clear glass jar. DO NOT compact the sand; leave it loose.
     - Slowly pour approximately one tablespoon of the dye solution over the sand.
       - Make initial observations.
       - Let sit for 10-20 minutes.
         - Make observations.
       - "Make it rain:" pour a small amount one to two tablespoons of clean water over sand.
         - Make observations.
3. Explain to students that this test shows the permeability of sand, which is the main particle size of most soil orders in Florida. They can add other particle sizes such as clay to compare. Students should observe that when the dye solution (representing fertilizer solutions) are added to sand they permeate past the rooting zone rather quickly. When it "rains," that percolation of solution only speeds up.
4. Finish up the "Blue Dye Test" with a discussion centering around the following:
   - Define the 4Rs of nutrient stewardship (see page 102)
     - Right Source
     - Right Rate
     - Right Time
     - Right Place
   - Guiding Questions
     - Where was the dye relative to the root system?
     - What environmental challenges might be presented when the blue dye (i.e., fertilizer) moves beyond the rooting zone?
     - How does soil texture and other qualities (slope, vegetation, surface permeability, etc.) affect water and nutrient movement through the soil?
     - How does that movement impact plant growth and productivity?

- Expert Tip! Helps students remember the 4Rs. After your discussion, assign students to groups of three to four. Give them seven-10 min to create a song, skit, newscast or commercial that helps other members of the class remember the 4Rs.

Activity 4: Nutrient Deficiencies

Expert Tip! If resources are limited Sub Activities 2 and 3 can be done as stations.

1. Introduce Plant Nutrient Deficiencies (amended from Nutrients for Life Foundation's H.S. Lesson 4). In this activity students will:
   - Recognize that like people, plants require essential nutrients present in the right amounts in order to be healthy.
   - Diagnose plant nutrient deficiencies using reference material.
   - Define fertilizer as a type of "food" for plants.
   - Explain that fertilizers are used to replenish nutrients in agricultural soils.
2. Sub Activity 1: When a Plant Needs Food (10 minutes)
   - When a Plant Needs Food Discussion
     - Ask, "How do plants get the nutrients they need for growth?"
       - If necessary, reference introduction celery absorption activity and use that as an anchor to this concept). Two important points should result from this question:
         - Plants require elements that are not supplied by photosynthesis.
         - Essential elements are found in the soil and absorbed by the plant through the root system.
     - Remind students that plants and people are both made of cells and those cells need nutrients in order to be healthy.
     - Ask, "What happens to us if we don't get enough of an essential nutrient?"
       - Answers will vary, but most should be able to point out that if we have a nutrient deficiency then we will likely get sick.
     - Think-Pair-Share
       - Say, "Predict what would happen to plants if they do not get the nutrients they need."
         - Accept all reasonable answers, but use probing questions to assess whether the students think the plant's response would be the same for all missing nutrients or whether there might be differences for different nutrients.
           - Think about your answer.
           - Pair up with the person next to you and compare answers. Formulate an answer that is as detailed as possible.
           - Share your answers with the rest of the class. Create a "super answer" and write it on the board or flipchart.
3. Sub Activity 2: Humanity Against Hunger (30 minutes) https://nutrientsforlife.org/for-students
   - Divide the class into groups of three. Each group will evaluate three case studies.
     - If computers are available, allow each student to work individually. See the Expert Tip! at the beginning of this activity for another option on splitting the class.
   - Students should access the "Humanity Against Hunger" activity at: https://www.nutrientsforlife.org/games/humanity/.
   - At the homepage, instruct students to begin by clicking on "The Food Crisis in Africa," and ask volunteers to read parts of the article.
   - Ask, "Can you think of ways to help solve Africa's food shortage problem?"
   - Instruct students to return to the home page and select "Your Assignment for Humanity Against Hunger." At this point, students will complete the web activity either in assigned groups or individually, following the directions given on the website.
   - When students have completed the assignment, you can have them print out their reports and turn them in as a form of evaluation.
   - As students finish, encourage them to explore the "Additional Resources/Links" Section.
4. Sub Activity 3: Plant Deficiencies (30 minutes)
   - In this activity students will evaluate plants (pictures at end of lesson) and determine which nutrient they believe the plant is deficient in. Using their knowledge from activity 1, students will be diagnosing nutrient deficiencies.
   - Extension Activity – Have students take soil samples from different areas of campus and ask your UF/IFAS Extension Office, listed on pages 174-177, to analyze the soil. This will allow the students to find out if the soil is deficient in nitrogen, phosphorus or potassium. If all analyses comes back with zero deficiencies then you have healthy soil around your campus and can complete this activity having students review which plant is showing a deficiency. If the soil samples come back with different deficiencies, have students match the deficiency pictures with the soil analysis.
   - Students will determine which fertilizer (1, 2, 3 or 4)

would best fit the deficient plants and explain why.

Extensions:

If you are looking for an additional agricultural experience for your students, consider doing a test garden. Use the following model (the Fort White Agriscience Program) as a guide.

1. Divide students into "gardening groups" (no more than four per group is recommended).
2. Tell students, "We are going to do an agricultural experiment to find out what effect plant spacing and fertilizer use has on plant health and productivity (using biomass)."
   - Biomass: For the purposes of this experiment, we are going to use "harvest weighed" as the biomass.
3. Develop a hypothesis in the form of an "if/then" statement. Example: If the population density of tomato plants is greater and fertilizer is added, then more tomatoes will be harvested.
4. Determine Variables:

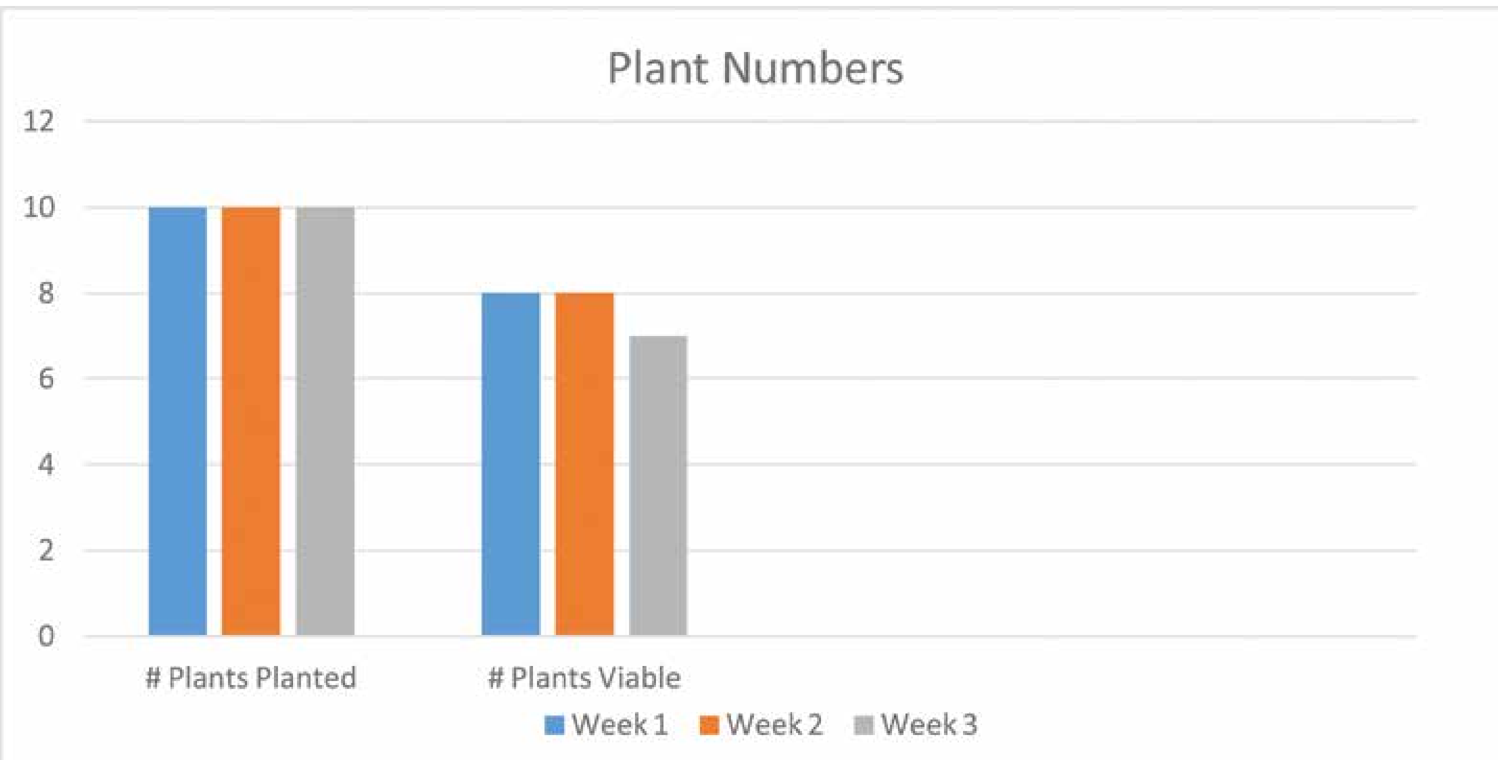
   - **Independent Variables** (x values):
     - Plant Treatments: Spacing/Population Density
       1. Closer spacing (teacher determined)
       2. Further spacing (teacher determined)
       3. Closer spacing with fertilizer (same spacing as treatment one, add recommended amount of fertilizer)
       4. Further spacing with fertilizer (same spacing as treatment two, add recommended amount of fertilizer)

   - **Dependent Variables** (y values): Note: Each group should keep a record book showing regular measurements of the dependent variables they have been assigned (recommended daily/every other day).
     1. Plant Health and Productivity
     2. Height
     3. Leaf Production (how many leaves)
     4. Viability/Mortality Rate per Row
     5. Biomass (harvest weight)

   - **Control:** Note: It is recommended that only one group per class OR teacher be in charge of the control plot so as to minimize disturbance and potential damage. The group or teacher will share regular measurements with the rest of the class.
     1. Recommended plant spacing as stated on the seed packet; no fertilizer.

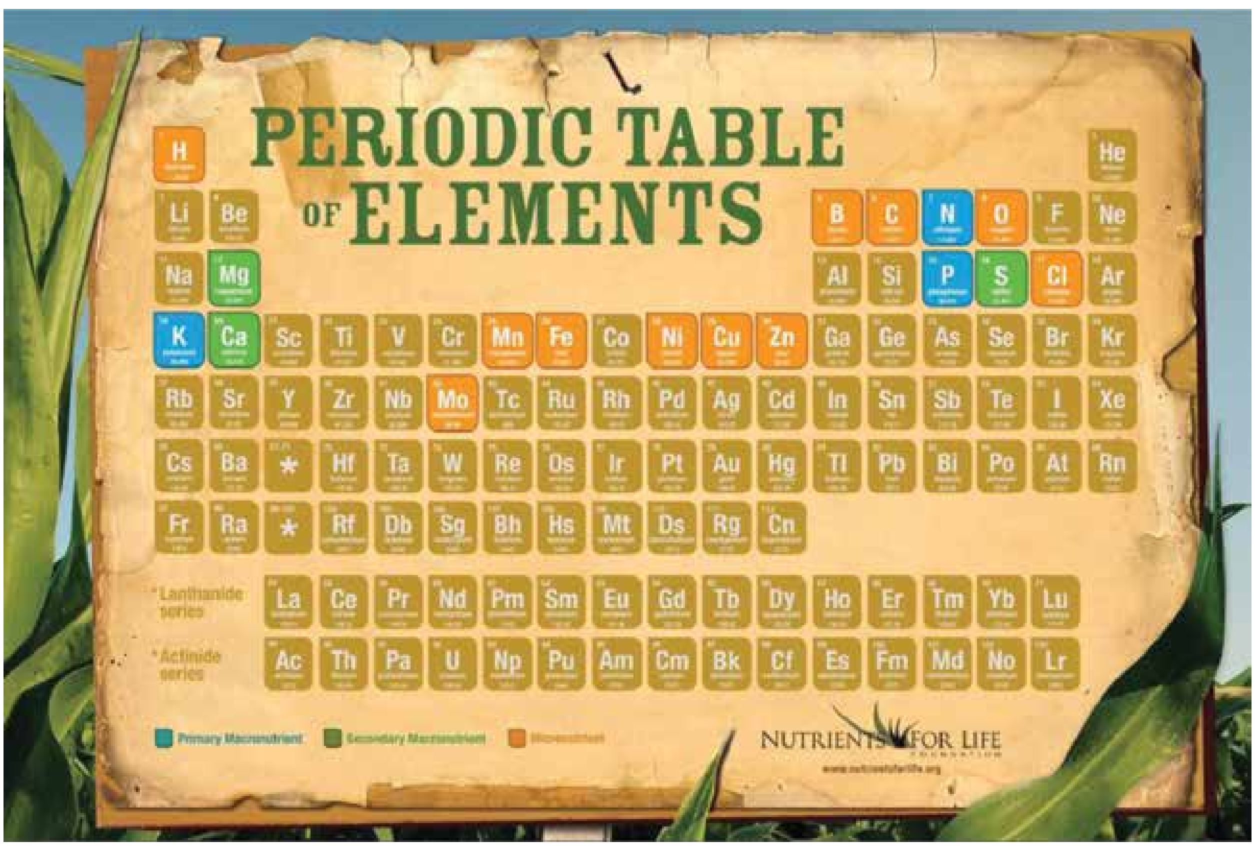
Example Group Data Record Keeping

Names & Group Number
Class Period & Date
Treatment Group: 3
Hypothesis (*hypothesis should correspond with treatment group assignment; you do not have to agree with your group's statement*): **If bell pepper plants are planted 16 inch apart and recommended amounts of fertilizer applied, then more peppers will be harvested.**
Daily/Bi-Daily Data: • Number of plants originally planted: 10 • Number of plants still viable: 8 • Average height of plants: 7.6 inch • Average leaf count: 26 leaves per plant • Average Fruiting: 2 per plant
Data Graphs *(Graphs can/should be done to illustrate comparisons of all relevant, measurable data collected)* Example:



***Note: As a class, make final recommendations. Which treatment was the most effective? Which was the least effective? Use a table like the one below to show the class sets of data and then insert that data into the graphs. Students can further extend this activity by presenting their findings and recommendations.

Group	Treatment	# Plants Planted	# of Plants Harvested	Harvest weight (Biomass) (lbs)	Average Height of Harvested Plants (HP)	Average Leaf Count of HP	Average Fruiting of HP
Control	Control						
A	1						
B	2						
C	3						
D	4						



Expert Group Nitrogen Information Sheet

- Nitrogen (N)-
  - The primary building block for all organisms. As a component of every amino acid it is vital in protein manufacture. As part of the chlorophyll molecule, nitrogen helps keep plants green and along with magnesium, is the only element in the chlorophyll molecule plants obtain from soil.
  - Vigorous plant growth is associated with adequate nitrogen nutrition, in part, because nitrogen plays a key role in cell division. Of course, cell division is essential to adequate leaf surface area without which photosynthesis would be limited and crop yields greatly reduced.
  - Nitrogen-deficient plants will present leaves that are light green to yellow, they will have low protein levels and poor fruit development.

Expert Group Phosphorus Information Sheet

- Phosphorus (P)-
  - Can be found in every living cell and serves as both a structural element and a catalyst for biochemical reactions. Phosphorus is the main component of DNA and ATP (the cell's energy molecule). It also plays vital roles in capturing sunlight during photosynthesis, helping with seed germination and the efficient use of water in the plant. Phosphorous also aids in overall plant hardiness and susceptibility to disease.
  - Phosphorus-deficient plants will exhibit purple colored leaves, stunted growth and delay in development, increased disease and reduced drought tolerance.

Expert Group Potassium Information Sheet

- Potassium (K)-
  - While not crucial to any important plant structure, it plays critical roles in several physiological functions: activates enzymes that catalyze chemical reactions involved in growth, balances water by regulating the opening and closing of the stomates, and assists in the regulation of rate of photosynthesis through its role in the production of ATP. Other aspects of plant health influenced by potassium include growth of strong stalks, protection from extreme temperatures and the ability to withstand stressors such as weeds and insects.
  - Potassium-deficient plants will show yellowing on the edges of older leaves and dead leaves. A potassium deficiency will also present as with irregular fruit development and reduced drought tolerance.

Blank Fertilizer Label

BRAND NAME		
GRADE X-X-X		
Guaranteed Analysis		
Total Nitrogen (N)........		________%
________%	Nitrate Nitrogen	
________%	Ammoniacal Nitrogen	
________%	Other / Water Soluble Nitrogen	
________%	Urea Nitrogen	
________%	Water Insoluble Nitrogen	
Available Phosphate (P_2O_5)........		________%
Soluble Potash (K_2O)........		________%
Chlorine, (Cl) Not More Than........		________%
________%	Water Soluble Magnesium as (Mg)	
________%	Chelated Magnesium as (Mg)	
________%	Manganese as (Mn)	
________%	Water Soluble Manganese as (Mn)	
________%	Chelated Manganese as (Mn)	
________%	Copper as (Cu)	
________%	Water Soluble Copper as (Cu)	
________%	Chelated Copper as (Cu)	
________%	Iron as (Fe)	
________%	Water Soluble Iron as (Fe)	
________%	Chelated Iron as (Fe)	
________%	Zinc as (Zn)	
________%	Water Soluble Zinc as (Zn)	
________%	Chelated Zinc as (Zn)	
________%	Combined Sulfur as (S)	
________%	Free Sulfur as (S)	
Derived from: (Actual materials and in forms used in the fertilizer mixture; e.g., diammonium phosphate, urea, potassium chloride, magnesium sulfate, manganese nitrate, etc.........		
Manufactured by: Name (FXXXX) City, State & Zip		
Net Weight - ________lb		

NPK Home Group Collaboration Table

	Nitrogen	Phosphorus	Potassium
What is it?			
Where does it come from?			
How is it helpful?			

Fertilizer Label Sample #1

Formulated with Urea for better uptake

Griffin 300

Griffin Fertilizer Company

GUARANTEED ANALYSIS

• Total Nitrogen	3.000%
• Available Phosphorous as P_2O_5	0.000%
• Soulble Potassium as K_2O	0.000%
• Iron as Fe (Chelated)	0.375%
• Manganese as Mn (Chelated)	3.000%
• Zinc as Zn (Chelated)	3.000%
• Boron as B	0.150%
• Copper as Cu	0.347%
• Molybdenum as Mo	0.006%

DERIVED FROM:

Urea, Iron, Manganese & Zinc Glucoheptonate, Copper Sulfate, Sodium Borate, Sodium Molybdate

Weight Per Gallon - 11.48 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN 300 is formulated with urea along with a balanced combination of essential micronutrients. These elements are in the correct ratios to provide the building blocks for the complex enzymatic reactions essential to overall plant health, production and disease resistance.
GRIFFIN 300 includes **Agro-Mos®** **by Alltech®**. **Agro-Mos®** is designed to enhance the natural systemic resistance within crops to crop-born challenges that limit production.

Foliar Nutritional Spray - **GRIFFIN 300** may be applied by air or with all types of ground spraying equipment.

Compatibility - **GRIFFIN 300** is compatible with most common foliar pesticides. USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products.

SUGGESTED USES - CITRUS CROPS

Mature Citrus - Apply 2-4 quarts of per acre.

Young Trees - Mix 2-4 quarts per one hundred gallons of spray solution and apply to runoff.

Fertilizer Label Sample #2

Griffin Dual Phos™ 3-18-18

Griffin Fertilizer Company

GUARANTEED ANALYSIS

• Total Nitrogen	3.00%
• Available Phosphorus as P_2O_5	18.00%
• Soluable Potassium as K_2O	18.00%

Statement of Secondary Plant Food

• Boron as B	.10%

DERIVED FROM:

Urea, Ammonium Hydroxide, Dipotassium Phosphate, Phosphorus Acid, Potassium Hydroxide, Sodium Borate

Weight Per Gallon - 11.72 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN DUAL PHOS™ 3-18-18 is a proprietary nutrient solution containing highly soluble forms of elements essential to plant growth, crop development, crop quality and yield.
DUAL PHOS™ is formulated with Dipotassium Phosphate (DKP).

- **DKP** has a very low salt index and can be safely applied at higher rates than many other products
- **DKP** provides readily available phosphorous as PO_4. At critical stages of plant growth, DKP enables the grower to bypass certain soil & environmental conditions that limit phosphorous uptake.
- **DKP** is much more soluble than potassium nitrate, therefore the DKP stays in solution on the leaf much longer - an essential requirement for foliar potassium uptake.

Patented **DUAL PHOS ™** includes phosphorous and phosphoric acid. The patent was granted after research proved that combining phosphates and phosphites in a single application is an innovative and superior method. The dual application provides a synergistic effect in which the inherent qualities of both products are amplified.
Foliar Nutritional Spray - **DUAL PHOS™** may be applied by air or with all types of ground spraying equipment.
Compatibility - **DUAL PHOS™** is compatible with most common foliar pesticides and nutrients. However, USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products.

SUGGESTED USES - CITRUS CROPS

Mature Citrus - Apply 3 - 4 gallons per acre. Each gallon supplies 0.50 pounds of Phosphorous Acid.

Young Trees - Apply 3 - 4 gallons per one hundred gallons of spray mix and apply to run-off.

Fertilizer Label Sample #3

Dual Phos™ & AGRO MOS inside

Griffin GREEN

Griffin Fertilizer Company

GUARANTEED ANALYSIS

- Total Nitrogen........ 4.000%
- Available Phosphorus as P_2O_5........ 14.000%
- Soluable Potassium as K_2O........ 10.000%
- Borom as B........ .200%
- Copper as Cu (Chelated)........ .161%
- Iron as Fe (Chelated)........ .110%
- Manganese as Mn (Chelated)........ .110%
- Molybdenum as Mo........ .001%
- Zinc as Zn (Chelated)........ .200%

DERIVED FROM:

Urea, Dipotassium Phosphate, Phosphorous Acid, Sodium Borate, (Copper, Iron, Manganese & Zinc EDTA), Sodium Molybdate

Weight Per Gallon - 10.95 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN GREEN contains Dual Phos™, a proprietary nutrient solution containing two highly soluble forms of phosphorus - Dipotassium Phosphate and Phosphorous Acid.

- **Dipotassium Phosphate** has a very low salt index and can be safely applied at higher rates than many other products.
- **Dipotassium Phosphate** provides readily available phosphorus and potassium that remain in solution on the leaf longer - an essential requirement for foliar phosphorus uptake.

GRIFFIN GREEN contains 1/2 pounds of pure phosphorous acid per gallon. Research has demonstrated that combining phosphates and phosphites (from phosphorous acid) in a single application is an innovative and superior method. The dual application provides a syngeristic effect in which the inherent qualities for both products are amplified.

GRIFFIN GREEN also includes **Agro-Mos®** from Alltech® Crop Science. **Agro-Mos®** is designed to enhance the natural systemic resistance within crops to crop-born challenges.

GRIFFIN GREEN includes a full complement of essential, soulble micronutrients. These elements are in the correct ratio to provide the building blocks for the complex enzymatic reactions essential to overall plant health, production and disease resistance.

Compatibility - GRIFFIN GREEN has a neutral pH and is compatible with most common foliar pesticides and nutrients. However, USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products. It may be applied by air or ground equipment.

SUGGESTED USES

Fruit Trees and Landscape Ornamentals - Apply 1-2 gallons in a minimum of 100 gllons of water per acre, or for dilute sprays, 1-2 gallons per 100 gallons of water and spray to full coverage.

Turf and Field Grown Ornamentals - Apply 1-3 gallons per acre (3-9 ounces per 1000 square feet) in a minimum of 100 gallons of water per acre, or inject through properly equipped irrigation system.

Greenhouses and Field Nurseries - Mix 1-2 quarts in 100 gallons of spray solution and spray to runoff every 14-21 days. Transplant Drench - Mix one quart per 100 gallons of water.

Fertilizer Label Sample #4

Griffin CA 825

Griffin Fertilizer Company

GUARANTEED ANALYSIS

- Total Nitrogen........ 7.000%
- Available Phosphorous as P_2O_5........ 0.000%
- Soulble Potassium as K_2O........ 0.000%
- Calcium as Ca........ 8.250%

DERIVED FROM:

Calcium Nitrate, Sodium Glucoheptonate

Weight Per Gallon - 11.86 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN CA 825 is a liquid foliar fertilizer containing a soluble and safe chelated calcium. It is formulated to aid in supplementing calcium levels in crops, especially during critical periods of growth.

Foliar Nutritional Spray - GRIFFIN CA 825 may be applied by air or with all types of ground spraying equipment.

Compatibility - GRIFFIN CA 825 is compatible with most common foliar pesticides. USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products.

SUGGESTED USES

Mature Citrus - Apply 2 - 3 quarts per acre.
Young Trees - Mix 2 - 3 quarts per one hundred gallons of spray solution and apply to runoff.
Vegetables - Apply 1 - 2 quarts per acre
Turf, Lawns, Sod - Apply 6 - 8 ounces per 1000 sq. ft.

Fertilizer Label Scavenger Hunt Worksheet

(the colors correspond to the different fertilizer labels)

- Brand Name: ______________________________
- Grade: ______________________________
- Guaranteed Analysis of this product: ______________________________
- Total Nitrogen: ______________________________
- Available Phosphorus: ______________________________
- Soluble Potassium: ______________________________
- Name at least two micronutrients along with their respective percentages: ______________
- Derived From: ______________________________
- Manufactured By: ______________________________
- Net Weight: ______________________________
- Application Instructions
    - o Calculate how much of this fertilizer you would use on a six-acre plot.
    - o How long would this product last if you fertilized weekly on your six-acre plot?

Picture of Nitrogen-Deficient Plant

Picture of Phosphorus-Deficient Plant

Picture of Potassium-Deficient Plant

Photos courtesy of Nutrients for Life Foundation.

STEMming Up Plant Nutrients

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. List three essential nutrients plants need.

2. Describe how plants "eat."

3. List and explain the 4Rs of nutrient stewardship.

4. Explain the relationship between soil particle size and water movement through soil.

5. Explain the relationship between the need for plant nutrients and feeding the world.

References:

Griffin 4-0-8. (n.d.). Retrieved September 23, 2015, from http://griffinfertilizer.com/

Hochmuth, G., Trenholm, L., Momol, E., Rainey, D., & Lewis, C. (n.d.). Conducting a Blue Dye Demonstration to Teach Irrigation and Nutrient Management Principles in a Residential Landscape1. Retrieved September 23, 2015, from http://edis.ifas.ufl.edu/ss594

Hurley, E., & Stewart, B. (2013, October 29). Using the Leaching Index in a Nutrient Management Plan. Retrieved September 23, 2015, from http://www.nrcs.usda.gov/wps/portal/nrcs/site/ia/home/

Intro to Fertilizer | TFI. (n.d.). Retrieved September 23, 2015, from https://www.tfi.org/introduction-fertilizer

Lehmann, J., & Schroth, G. (n.d.). Nutrient leaching. Trees, Crops and Soil Fertility: Concepts and Research Methods, 151-166. Retrieved September 23, 2015, from http://www.css.cornell.edu/faculty/lehmann/publ/Lehmann et al., 2003, Leaching CABI book.pdf

Natural Resources Conservation Service. (n.d.). Retrieved September 23, 2015, from http://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/

Nutrients For Life. (n.d.). Retrieved September 23, 2015, from https://www.nutrientsforlife.org/

Oelfke, W. (2015, August 1). Helping Communities Grow Project [Personal interview]

Overdahl, C., Rehm, G., & Meredith, H. (n.d.). Fertilizer urea. Retrieved September 23, 2015, from http://www.extension.umn.edu/agriculture/nutrient-management/nitrogen/fertilizer-urea/

Sartain, J. (1980, November 1). The Florida Fertilizer Label1. Retrieved September 23, 2015, from http://edis.ifas.ufl.edu/document_ss170